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(54) ELECTRICAL CABLE, PREFERABLY HIGH-VOLTAGE CABLE

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Electrical Cable, Preferably High-Voltage Cable

The invention relates to an electrical cable, preferably a high-voltage cable, whose insulation consists of an olefin polymer. The term cable, here and below, also denotes lines.

For the insulation of such a cable, one can use, in particular, polyethylene, namely either high-pressure polyethylene or low-pressure polyethylene, as well as crosslinked polyethylene. However, for this purpose it is also possible to consider using other polymers or copolymers based on ethylene, propylene, or homologs thereof, as well as copolymers of this type, which contain, as a third component, an unsaturated hydrocarbon, in particular a diene. Special copolymers of this type are known under the name ethylene-propylene terpolymer rubber (EPDM).

It is known to add two cable insulations based on olefin polymers, in particular based on polyethylene, small quantities of a hydrocarbon, such as, tristyrene, α- or β-methylnaphthalene, or dodecylbenzene (OE-PS 207 561). Furthermore, for such cable insulation, it is known to add small quantities of unsaturated, perhalogenated hydrocarbon compounds having a melting point below 20°C and a boiling point above 120°C (DT-AS 1 141 081), or of bisbenzyltoluene (DT-AS 1 490 574), and of solid aromatic hydrocarbon compounds dispersed in hydrocarbon oils (DT-OS 1 569 396), as well as N-phenyl-N'-isopropyl-p-phenylenediamine and/or N-phenyl-n''-cyclohexyl-p-phenylenediamine and/or carbazole and/or acridine (DT-PS 1 490 575), and diphenyl-p-phenylenediamine (Transact. AIEE, Vol. 81, Part. III, June 1962, p. 115).

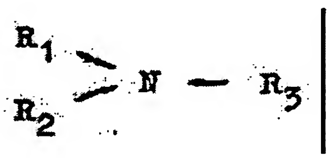
The invention, to solve the problem, provides an improvement of a cable insulation, in particular for high-voltage purposes, with such insulation being based on an olefin polymer, in particular a polymer or copolymer based on ethylene.

According to the invention, the cable insulation contains a small addition of aliphatic, aromatic, or mixed aliphatic-aromatic, saturated tertiary mono-, di- ,or polyamines, whose substituents are pure hydrocarbons. Thus, it is essential for the invention that, as the additive, a saturated tertiary amine is used, and that the latter compound contains no heteroatoms. The entire

molecular structure of the additives used in the context of the invention thus only contains pure hydrocarbon groups as well as tertiary amines.

The structure of the cable insulation provided according to the invention results in a considerable improvement of the electrical properties, namely in particular the long-term rigidity.

The saturated tertiary mono-, di-, or polyamines provided in the context of the invention have the following structure:



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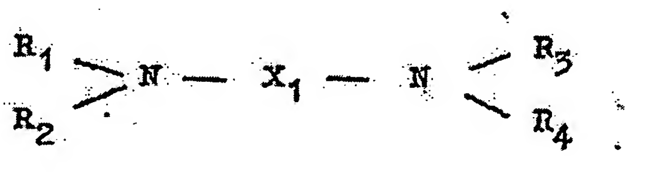
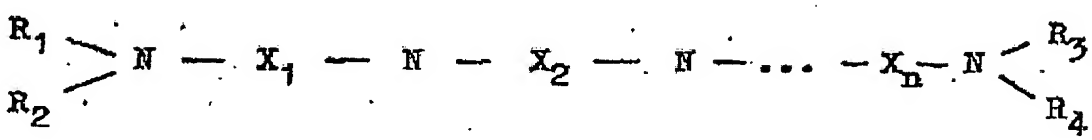
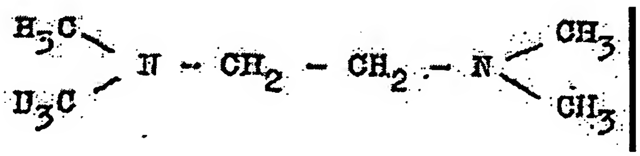


or in general



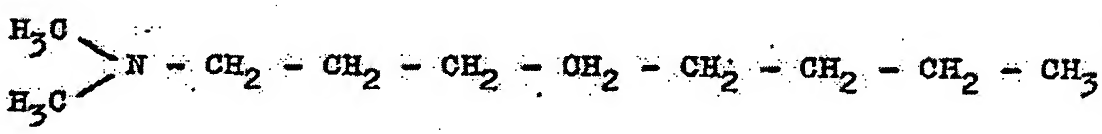
Here, the substituents R_1-R_4 as well as X_1-X_n are alkyl, aryl, cycloalkyl, or cycloaryl groups, that is aliphatic, aromatic, cycloaliphatic, or cycloaromatic groups; these groups can also be mixed aliphatic-aromatic. They can be identical to each other or also different from each other. The only essential condition is that they are pure hydrocarbons, which thus contain no heteroatoms.

Examples of suitable compounds are: trialkylamines, such as trimethylamine or triethylamine. Additional examples are



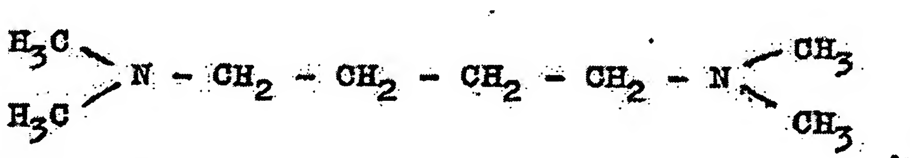
(N,N,N',N'-tetramethylethylenediamine)

or



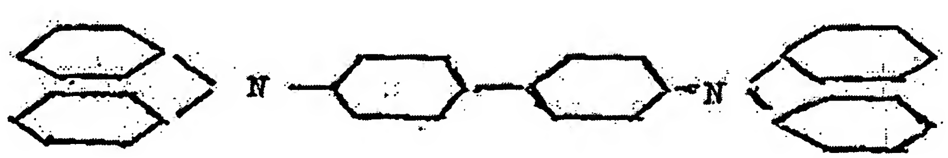
(N,N-dimethyloctylamine)

or



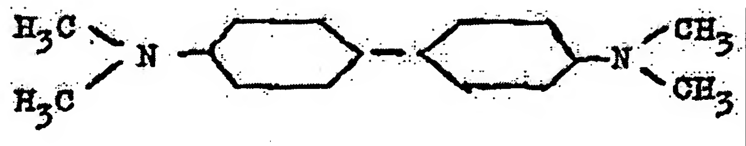
(N,N,N',N'-tetramethyldiaminebutane)

or



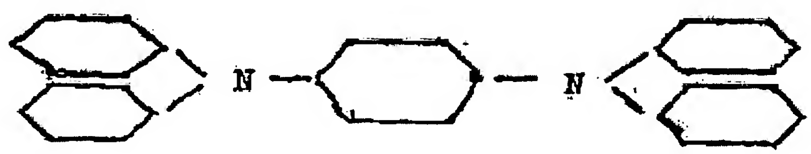
(N,N,N',N'-tetraphenylbenzidine)

or



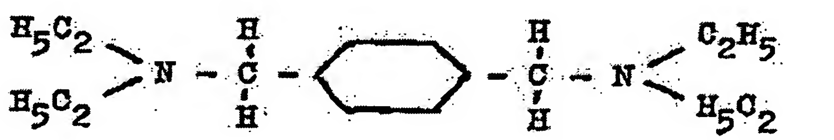
(N,N,N',N'-tetramethylbenzidine)

or



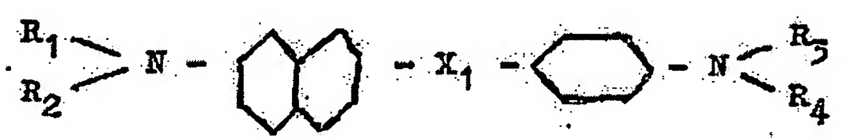
(N,N,N',N'-tetraphenyl-p-phenylenediamine)

or



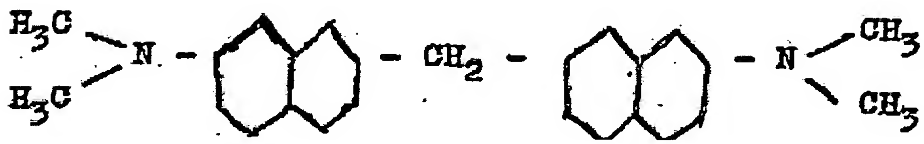
(N,N,N',N'-tetraethyl-p-xylene-α,α'-diamine)

or



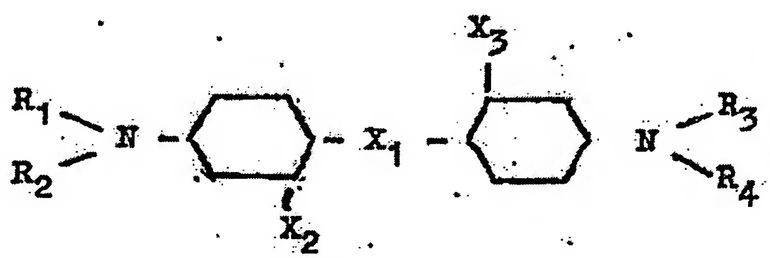
(tetra-substituted naphthylenephenylenediaminoalkane)

or



(N,N,N',N'-tetramethyldinaphthyldiaminomethane)

However, the aromatic groups can also be substituted with additional pure hydrocarbon groups. This leads to saturated tertiary amines having, for example, the following structure:



It has been shown that it is advantageous, for carrying out the concept of the invention, to use tetraalkyldiaminodiarylalkanes, such as, N,N,N',N'-tetraethyl-p-xylene-α,α'-diamine or N,N,N',N'-tetramethyldiaminodiphenylmethane. It is particular advantageous to use a cable insulation based on polyethylene to which 0.5-0.8 % tetramethyldiaminodiphenylmethane has been added.

Thus, the test of the short-term resistance [rigidity] in the form of an immediate breakdown test which is carried out on a model cable having a wall thickness of 0.5 mm of the conductor polishing material based on polyethylene vinyl acetate and a model cable having a wall insulation thickness of 1.0 mm yielded the following values, which are placed for comparison next to the values of a model cable constructed in a similar manner, but with the addition of 0.08% diphenyl-p-phenylenediamine to the polyethylene insulation:

Polyethylene insulation contains

	0.08 wt% diphenyl-p-phenylenediamine	0.5% tetramethyldiaminodiphenyl methane
50% value	54 kV/mm	65 kV/mm
70% value	60 kV/mm	78 kV/mm
95% value	73 kV/mm	95 kV mm

Tests of the long-term resistance using the Würstlin test, and on the same polyethylene type, have shown that the addition of a 0.5 wt% diphenyl-p-phenylenediamine at a 30-kV test voltage yields a median value of 70 h, while the addition of tetramethyldiaminodiphenylmethane under identical conditions yields a median value of 1800 h.

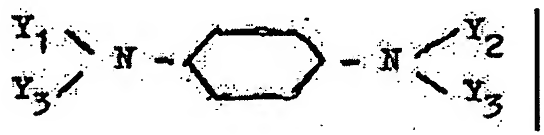
Testing of the long-term resistance using the double needle test, for cable insulation based on polyethylene with the addition of 0.5% tetramethyldiaminodiphenylmethane, yields substantially higher values of electrical field strength, without any occurrence of ionization or breakdown, in contrast to what occurred with an identical cable insulation with the addition of diphenyl-p-phenylenediamine.

In addition, one must also take into account the fact that, as tests have shown, diphenyl-p-phenylendiamine at 80°C evaporates within 2 h in a proportion of 90%, while the evaporation tests of trimethyldiaminodiphenylmethane resulted in only 10% evaporation under identical conditions. This is of particular importance in view of the operational temperature of polyethylene insulated high-voltage cables, which is considerably higher than room temperature, and which at this time is allowed to reach a maximum of 70°C.

Furthermore, the degree of purity of commercially available tetramethyldiaminodiphenylmethane is higher than that of diphenyl-p-phenylenediamine. The last mentioned compound indeed, in the state in which it is delivered, like all secondary amines, always contains its own oxidation products as well as, in this special case, diphenylamine as a contaminant, so that the melting range of commercially available diphenyl-p-phenylenediamine is 120-143°C. In contrast, the commercially available trimethyldiaminodiphenylmethane, in the condition in which it is delivered, melts at 82-87°C.

With regard to the performance factor, a cable insulation made of polyethylene with the addition of 0.8 wt% tetramethyldiaminodiphenylmethane has the same tan δ value of 1.4×10^{-4} as a cable insulation of the same polyethylene type with the addition of only 0.05 wt% diphenyl-p-phenylenediamine.

While diphenyl-p-phenyldiamine is a secondary aromatic amine with antioxidative properties, amines, such as, in particular, tetramethyldiaminodiphenylmethane, present no antioxidative properties. In itself, it is known (DT-OS 2 030 972) to use compounds having the structure



with

Y_1: phenyl or alkylphenyl group

Y_2: alkyl group having 1-8 C atoms or cycloalkyl group having 5-9 C atoms, or N,N'-dialkyl-N,N'-diaryl-1,4-arylenediamine or N,N'-di(β-hydroxyalkyl)-N,N'-diaryl-1,4-arylenediamine, and

Y_3: alkyl group having 1-4 C atoms

as antioxidants for peroxide crosslinked polyethylene formed [molding] compositions. The claims concerning the antioxidative efficacy of these compounds for peroxide-crosslinked polyethylene formed [molding] compositions are based on measurements of the tensile strength and the expansion. However, it has been shown that compounds of this type, in the case of noncrosslinked polyethylene insulations, are nearly ineffective against the action of oxygen.

In a variant of the invention, it is therefore recommended to add an antioxidant, in a manner that in itself is known, to the mixture based on an olefin polymer, which is used as cable insulation, and which contains an additive of saturated tertiary amines. It is possible to consider, for this purpose, for example:

4,4-thiobis-(3-methyl-6-tert-butylphenol)

N-phenyl-1-naphthylamine, or

β-(3,5-di-tert-butyl-4-hydroxyphenyl)propionic acid ester of pentaerythritol.

To explain the invention, a single conductor high-voltage cable designed according to the invention is shown in a perspective view in the figure.

The conductor of this cable consists of braided copper wires, to which the conductor polishing material 2 made of polyethylene vinyl acetate is applied.

In the extruder, the polyethylene insulation 3 is sprayed onto the conductor polishing material 2. In carrying out the concept of the invention, this polyethylene insulation 3 consists of a high pressure polyethylene having a molecular weight of approximately 80,000, to which 0.5 wt% tetramethyldiaminodiphenylmethane has been added.

In a manner that is known in itself, an antioxidant, for example, 4,4'-thiobis-(3-methyl-6-tert-butylphenol) in a quantity of 0.05-1 wt% is added to the polyethylene insulation 3.

The external field delimitation 4 consisting of polyethylene vinyl acetate is sprayed onto the polyethylene insulation 3. The field delimitation 4 is surrounded by the screen 5 made of copper wires, which in turn is enclosed by the counter filament 6 made of a copper band.

Toward the outside, the represented cable is surrounded by the protective jacket 7 made of polyvinyl chloride.

1 Figure
5 Claims

Claims

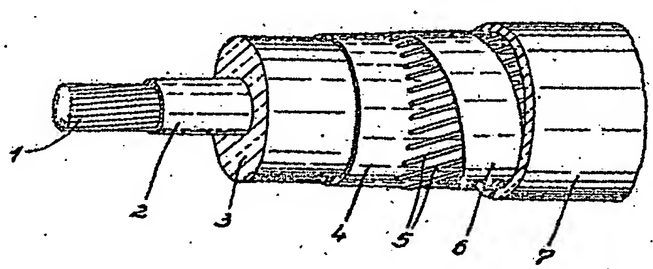
1. Electrical cable, preferably a high-voltage cable, whose insulation consists of an olefin polymer, in particular of a polymer or copolymer based on ethylene, characterized in that the cable insulation contains a small addition of aliphatic, aromatic or mixed aliphatic-aromatic, saturated tertiary mono-, di-, or polyamines, whose substituents are pure hydrocarbons.

2. Electrical cable according to Claim 1, characterized in that the saturated tertiary mono- di-, or polyamines are added in a quantity of 0.1-2 wt%, preferably 0.5-0.8 wt%.

3. Electrical cable according to Claims 1 and 2, characterized in that the added amine is a tetraalkyldiaminodiacrylalkane.

4. Electrical cable according to Claim 3, characterized in that the added amine is a tetramethyldiaminodiphenylmethane.

5. Electrical cable according to Claim 1, characterized in that one adds an antioxidant, which in itself is known, to the mixture used as cable insulation, and based on a polyolefin polymer, which contains a small addition of a saturated tertiary amine.



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